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UPPER WINDS AT KINGSTON, JAMAICA

By S. PROUD, B.A.

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UPPER WINDS AT KINGSTON, JAMAICA

By S. PROUD, B.A.

Introduction.—The data which form the basis of this note are the results of pilot balloon observations made at Kingston, Jamaica, during the period May, 1925 to February, 1936. During this period of more than 10 years, some exceptionally high levels were reached and a sufficient number of the balloons were followed to 10 Km. (33,000 ft.) to justify the presentation of frequency tables and wind roses up to that height. The observations were made under the personal direction of Mr. J. F. Brennan, the Government Meteorologist of the Jamaica Weather Service, and they constitute an extremely valuable set of results, particularly on account of the great regularity of the ascents and the unusually high levels reached.

Kingston is situated in Lat. 18° N., Long. 77° W., on the southern coast of Jamaica and is sheltered to the north and north-east by the Blue Mountains which rise to a height of over 2 Km. (7,000 ft.). It is, also, partially protected from N. and NW. winds and from the full violence of the northers(1)* of the Gulf of Mexico by the central mountain ranges of the island.

The method of observation adopted was that known as the single theodolite method, the high frequency of light winds at low levels preventing the use of the tail method. As usual, with this method of observation, the results are based on an assumed rate of ascent of the balloon so that deviation from this rate of ascent, due to vertical currents, may have given rise to appreciable errors on some occasions. One ascent was made daily, weather permitting, namely at 0700 local time.

Monthly frequency tables have been prepared from the results in the form recommended by the International Commission for Air Navigation and these are presented here as Tables VII to XVIII. Wind roses have been drawn for each month for the various heights given in the tables, with the exception of the surface observations, and these appear as Figs. 1–6 (at end of note). Their interpretation is as follows :—The total length from the circumference of the circle to the end of the arrow represents the total percentage frequency of winds from that particular direction. The frequency of winds of various speeds from any one direction are shown by widening and shading the arrows in accordance with the scheme presented at the top of each diagram. The circle supplies a scale for the ready estimation of the frequency of winds from any direction, the radius of the circle representing a frequency of five per cent of the whole number of observed winds on which any particular wind rose is based. The

* The numbers in brackets refer to the bibliography on p. 14.

upper figure inside the circle gives the percentage of winds less than three miles per hour experienced, whilst the lower figure shows the total number of observations on which the wind rose is based.

Normal pressure distribution and atmospheric circulation at Jamaica.—In January the sub-tropical anticyclone of the North Atlantic Ocean normally lies between 25° and 35° N. and to the north-east of Jamaica, while a large part of the United States and Canada is covered by a continental anticyclone. These two high pressure systems are separated by the Atlantic Polar Front on which many of the depressions of temperate latitudes form. When such a depression appears over the southern United States or in the Gulf of Mexico the cold air in the rear of it (i.e. behind the cold front) may penetrate as far south as Jamaica, so that the front may pass Kingston and the resulting norther will be associated with deviations from the normal air currents at Jamaica in the lower layers of the troposphere. South of Jamaica at all seasons of the year lies the tropical belt of low pressure which has a north and south seasonal oscillation and whose mean annual position is just north of the equator. As summer advances the sub-tropical anticyclone over the Atlantic intensifies and moves north, its centre being found in August between 30° and 40° N. To the south-westward it extends as far as the Gulf of Mexico and the south-east states of America. The remainder of the North American continent is normally covered by low pressure systems in summer.

Jamaica is consequently in general within the region of the north-east trade wind throughout the year, which wind will hereafter be referred to as the trade. The trade may, however, blow from E. or even SE. at Kingston. In the vicinity of the West Indies the northern limit at the earth's surface of the trade shows a seasonal oscillation between its southernmost position in latitude 24° N. during March to its northernmost position in latitude 28° N. in September, and the surface of separation between the trade and the westerly winds of temperate latitudes slopes upwards towards the south(2)(3). These westerly winds will be referred to as the counter trade. It is to be expected, therefore, that the wind at Jamaica will be predominantly north-easterly or easterly in the lower part of the troposphere and will become westerly at some height which is likely to vary with the seasonal movement of the trade wind belt.

Surface winds.—The tables indicate that the great majority of surface winds are light and from the north ; this is to be attributed to the fact that the ascents were made at about 0700 when the off-shore breeze, probably augmented by a katabatic wind from the mountains north of Kingston, determines the surface wind. The percentage of winds less than 3 m.p.h. at that hour has a minimum in January and a maximum in October ; otherwise, little seasonal variation in the surface wind regime is revealed. Northerly surface winds, if due solely to land breeze or katabatic effects, rarely extend

upwards beyond 250 m. (800 ft.), but if they are reinforced by a gradient wind from the north, as in the case of the northers, they may reach to considerably greater heights. No information regarding surface winds at other times of the day is provided.

The trade and counter trade.—In general, the trade is encountered within the first kilometre (3,000 ft.) throughout the year, blowing from east or south-east in the majority of cases. The height at which the combined frequency of E. and SE. winds is greatest is 2 Km. (6,000 ft.) in all months, and from June to August over 90 per cent of winds are from one or other of these directions at that height. In November this percentage falls to its lowest value, viz., 69 per cent.

The high constancy of easterly winds is the first outstanding feature of the tables and wind roses ; the second is the almost complete reversal from easterly to westerly winds (i.e. from trade to counter trade) at greater heights, which is prominent in the diagrams for the months November to May. The effect is not so pronounced in other months, but the highest ascents indicate the existence of this reversal at levels above 10 Km. (33,000 ft.).

The transition from trade to counter trade normally takes place within a layer of 1 Km. (3,000 ft.) but, owing to the fact that the actual height at which this reversal occurs may vary considerably from day to day, combined with the seasonal variation, the wind roses suggest a more gradual transition. Usually the nature of the change from trade to counter trade is a gradual backing of the wind through north, so that the transition belt itself is commonly characterized by light winds from some northerly point. On occasion however the wind may veer through south to west, or the easterly wind may decrease gradually and give way to a light westerly wind increasing with height. In this last case the transition zone is one of light winds from east or west.

Table I indicates the wide variations in the height of the base of the counter trade. In constructing it the height of the counter trade has been taken as that height at which a wind with a westerly component is first reached, always provided that above that height westerly winds continue. Since many ascents do not reach 10 Km. (33,000 ft.) it is clear that the chance of observing a low counter trade is greater than the chance of observing a high one. An attempt to obviate this effect has been made by the inclusion in the table of those ascents only which were followed to 9 Km. (30,000 ft.) or more. This height has been selected in this connexion since a large number of ascents terminated there, and a table similarly constructed for a limit of 10 Km. (33,000 ft.) would have been based on considerably fewer observations. The last column but one shows the number of occasions on which the counter trade was not reached and when it must consequently have been at least higher than 9 Km. (30,000 ft.).

TABLE I.—FREQUENCY TABLE OF THE HEIGHT OF THE COUNTER TRADE IN ASCENTS REACHING TO AT LEAST 9 KM. (30,000 FT.)

Height. Km.	1	2	3	4	5	6	7	8	9	10	11	12	Not reached.	No. of observations.
Height. ft. $\times 10^3$	3	6	10	13	17	20	23	27	30	33	37	40		
January ..	..	1	3	5	14	12	6	12	5	2	..	..	3	63
February..	..	4	6	5	13	6	5	3	4	2	..	..	4	52
March ..	1	..	5	9	15	10	2	1	..	..	..	..	1	44
April ..	..	..	2	12	17	4	4	2	2	1	..	..	2	46
May ..	1	..	4	18	13	7	10	3	2	3	..	..	8	69
June ..	..	..	2	1	7	7	7	4	3	1	3	1	15	51
July ..	..	..	..	..	1	4	6	4	5	3	1	..	16	40
August ..	..	..	..	..	1	5	6	4	6	5	..	1	40	68
September	..	..	1	1	9	1	9	4	3	1	..	..	28	57
October ..	..	..	2	3	3	2	10	6	7	4	..	1	27	65
November	3	1	4	3	12	11	9	8	4	3	2	1	7	68
December	..	..	11	5	10	10	10	9	3	6	..	..	14	78

The most striking feature of this table is the high frequency with which the counter trade was not met below 9 Km. (30,000 ft.) from June to October. In August, in particular, such was the case in about 60 per cent of the ascents reaching that height. From January to April, however, an ascent to 9 Km. (30,000 ft.) will almost invariably reach the W. winds, commonly at a height of 5 Km. (17,000 ft.) ; exceptionally, the counter trade descends to 1 Km. (3,000 ft.) and, as will be shown later, the trade may be absent at all heights in such cases.

Above the counter trade.—It has been pointed out by Shaw (4) that, since the horizontal temperature gradient in the stratosphere is from high temperature over the poles to low temperature over the equator, the normal horizontal gradient of pressure in the lower layers of the troposphere (low pressure over the poles and high over the equator) will be diminished above a certain height and will ultimately be reversed ; above the reversal height easterly winds will occur. Ascents which reached 15 Km. (50,000 ft.) or over are given in Table II and it will be observed that on October 6, 1928, a balloon, followed to 26 Km. (87,000 ft.), was in these easterly winds from 19 Km. (63,000 ft.) to the top of the ascent. On two other occasions, November 15, 1926 and September 4, 1934, these easterly winds were observed at 13 Km. (43,000 ft.) and 15 Km. (50,000 ft.) respectively. These high ascents of Table II also demonstrate how, once established, the counter trade generally extends through a considerable height.

Effect of strong easterly winds at low levels.—A strong easterly wind at low levels may cause a balloon to be lost to view in the distance before attaining any great height, and in order to assess

TABLE II.—ASCENTS WHICH WERE FOLLOWED TO

Height. Km.	0	1	2	3	4	5	6	7	8	9	10
Height. ft.×10³	0	3	7	10	13	17	20	23	27	30	33
February 15, 1926	N. 7	ESE. 27	SSE. 5	SE. 5	ESE. 11	SE. 25	E. 5	WSW. 7	NW. 16	N. 27	WNW. 20
November 12, 1926	N. 5	ESE. 16	SE. 11	E. 11	E. 9	ENE. 9	NE. 9	N. 7	NNW. 7	SSW. 5	SW. 9
November 15, 1926	NNE. 5	ESE. 18	SE. 14	E. 7	S. 2	NNW. 5	NE. 9	ENE. 9	NE. 9	NW. 5	W. 7
November 27, 1926	N. 9	NE. 2	E. 9	E. 9	NE. 9	N. 2	NNW. 7	N. 9	WSW. 5	W. 18	WNW. 16
May 14, 1927	N. 2	E. 23	E. 25	ENE. 7	ESE. 7	S. 7	S. 5	ENE. 5	NNW. 9	NNW. 16	WNW. 16
October 6, 192	NNW. 2	ESE. 7	ENE. 14	ENE. 11	NE. 7	NNE. 2	S. 7	SSW. 7	S. 7	S. 7	SSW. 9
August 9, 1934	NNE. 9	E. 27	ESE. 23	E. 18	ESE. 20	ESE. 14	ESE. 18	S. 11	SW. 7	W. 7	WNW. 11
August 11, 1934	ESE. 2	ESE. 29	E. 14	E. 9	ENE. 9	Calm	WSW 14	WNW. 2	SW. 9	WSW. 9	W. 11
September 4, 1934	N. 5	ESE. 18	E. 9	E. 11	ENE. 11	ENE. 11	ENE. 11	S. 7	WSW. 14	SW. 11	WNW. 16
September 6, 1934	NNE. 5	E. 14	SE. 7	SSE. 7	ENE. 2	N. 5	NE. 9	NNE. 11	N. 14	NNW. 11	NW. 9
December 19, 1934	N. 7	ESE. 20	ESE. 18	SE. 20	SE. 14	ESE. 14	NE. 14	NNE. 14	NW. 20	WNW. 29	W. 29

the significance of the wind roses, it is essential to know to what extent such effects as this may vitiate the deductions made. Table III indicates the number of occasions on which a balloon, revealing a wind speed of 30 m.p.h. or more at any level between the surface and 3 Km. (10,000 ft.), was lost at various heights.

The winds of 30 m.p.h. or more which are considered in the above table were easterly, usually blowing from some point between ENE. and ESE. Clearly the majority of the balloons which experienced such winds in the lower levels were not followed above 5 Km. (17,000 ft.). Those ascents which were followed higher have been separately examined to discover what connexion, if any, existed between a high speed in middle layers and the height of the counter trade. Sixty-three occasions were recorded on which the balloon was observed as high as, or higher than 7 Km. (23,000 ft.)—one being followed to 16 Km. (53,000 ft.)—although speeds had reached 30 m.p.h. in the first 3 Km. (10,000 ft.) of the ascent. Of these balloons, 34 reached the counter trade before being lost. The existence of strong easterlies in the trade belt does not seem materially to affect the counter trade, though necessarily precluding its descent to the low levels recorded on rare occasions (see Table I).

On August 14, 1934, for example, the wind was from E. or SE. up to 4 Km. (13,000 ft.) and attained a speed of 32 m.p.h. at 1 Km. (3,000 ft.) which was maintained for 1 Km. (3,000 ft.).

AT LEAST 15 KM. (50,000 FT.). Speeds are in m.p.h.

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
37	40	43	47	50	53	57	60	63	67	70	73	77	80	83	87
WNW. 23	WNW. 34	WNW. 50	WNW. 52	WNW. 50	..	..	..	..	..	..	..	..	..	..	..
W. 11	W. 23	W. 11	SW. 11	SSW. 11	W. 16	..	..	..	..	..	..	..	..	..	..
NW. 14	N. 14	NE. 11	NNE. 34	ENE. 50	..	..	..	..	..	..	..	..	..	..	..
NNW. 38	WNW. 41	WNW. 50	W. 34	W. 34	W. 36	..	..	..	..		..	..	..	..	..
NW. 38	WNW. 29	W. 52	WNW. 45	WNW. 23	..	..	..	..	..	..	..	..	..	..	..
SW. 14	WSW. 29	WSW. 32	WSW. 29	SW. 20	WSW. 20	WNW. 23	SSW. 14	ENE. 5	ESE. 14	SE. 20	ESE. 32	ESE. 36	ESE. 29	ESE. 27	SSE. 27
W. 18	WSW. 32	WSW. 32	WSW. 23	WSW. 23	..	..	..		..	..	..	..	..	..	..
WNW. 18	WNW. 27	WNW. 18	W. 14	SW. 29	SW. 27	..	..	..	..	..	..	..	..	..	..
WNW. 20	SSW. 11	WSW. 25	SSW. 11	E. 5	ENE. 23	E. 54	..	..	..	..	..	..	..	..	..
NNW. 7	NW. 2	WNW. 2	W. 11	WSW. 11	W. 23	NW. 29	NW. 29	..	..	..	..	..	..	..	..
WNW. 36	W. 18	NW. 16	WNW. 29	WNW. 45	..	..	..	..	..	..	..	..	..	..	..

TABLE III.—TABLE SHOWING THE NUMBER OF OCCASIONS ON WHICH A BALLOON WAS LOST AT ANY GIVEN HEIGHT when the wind had attained a speed of 30 m.p.h. or more in the first 3 Km. (10,000 ft.) of the ascent.

Followed to Km.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Followed to ft. × 10^3	3	7	10	13	17	20	23	27	30	33	37	40	43	47	50	53
January ..	..	14	11	6	8	5	..	..	..	1	..	..	..	..	..	..
February ..	1	5	14	6	9	4	..	..	..	..	..	..	..	..	..	..
March ..	5	5	10	7	3	1	1	..	1	..	..	..	..	..	..	..
April ..	1	4	8	2	2	2	..	..	..	1	..	..	..	..	..	..
May	3	13	15	9	6	..	2	1	2	1	..	..	1	..	..	..
June.. ..	2	31	26	21	10	3	2	1	3	3	..	1	2	..	..	..
July ..	..	21	49	31	21	13	4	2	6	4	2	1	..	..	..	..
August ..	..	9	26	20	12	5	4	2	2	1	1	..	..	..	..	1
September ..	1	7	17	10	1	5	1	..	1	2	..	..	..	..	..	..
October ..	..	3	6	10	1	..	..	..	..	1	1	..	..	..	..	..
November ..	..	..	4	5	..	..	..	..	..	..	..	..	..	..	..	..
December ..	..	..	9	8	5	2	3	1	..	..	..	..	..	..	..	..

TABLE IV.—LIGHT WESTERLIES (Less than 10 m.p.h. and, in the majority of cases, less than 5 m.p.h.)
Table showing the height to which a light westerly wind, immediately above the land breeze, extends.

Westerly extended to	Km.	0·25	0·5	0·75	1·0	1·5	2·0	2·5	3·0	3·5	4·0	4·5	5·0	6·0	7·0	8·0	9·0	10·0	11·0	12·0	13·0	14·0
	ft. × 10^3	0·8	1·7	2·5	3·3	5·0	6·7	8·3	10	12	13	15	17	20	23	27	30	33	37	40	43	47
January		29	44	45	6	3	1	..	..	*1*	1 *1*	..	..	*1*	..	..	..	..	..	..	..	..
February		35	32	36	6	2	1	*2*	*1*	..	..	*1*	*1*	*3*	*1*	*2*	..	..	..	..	..	..
March		24	27	34	11	1	..	..	*1*	..	*1*	*1*	*2*	*1*	*2*	*1*	..	..	..	..	..	..
April		24	24	15	9	1	..	*1*	..	..	..	..	..	..	..	..	..	..	..	..	..	..
May		25	22	8	2	..	..	*1*	..	*1*	..	..	..	*1*	..	..	..	*1*	..	..	..	..
June		29	8	6	1	..	..	..	..	..	..	*1*	..	..	..	..	..	..	..	..	..	..
July		41	19	14	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
August		39	26	25	10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
September		28	20	17	13	..	1	..	..	..	*1*	..	*1*	..	..	..	..	..	..	..	..	..
October		36	22	23	8	3	..	..	..	..	..	..	*1*	*1*	..	..	..	..	..	..	..	..
November		33	41	46	15	3	..	*2*	*1*	*2*	1 *1*	1	..	1 *1*	*1*	..	*1*	*1*	..	..	..	*1*
December		39	46	40	8	2	1	..	..	..	1	*1*	..	*1*	..	..	*1*	..	..	..	..	..

The counter trade was reached at 7 Km. (23,000 ft.) where a west wind of 5 m.p.h. was observed ; above that height the westerlies increased to 30 m.p.h. at 11 Km. (37,000 ft.) after which the balloon was lost. On January 19, 1936, the wind at the surface was from ESE. (an exceptional wind, as the wind roses show), which direction it maintained up to 1 Km. (3,000 ft.). The speed increased from 23 m.p.h. at the surface to 36 m.p.h. at 250 m. (800 ft.) and was greater than 30 m.p.h. up to 1·5 Km. (5,000 ft.) ; above this height it gradually diminished in speed and then backed, and at 4 Km. (13,000 ft.) the counter trade was met and westerly winds were then observed up to 10 Km. (33,000 ft.) where the speed was 54 m.p.h. and the balloon was lost. This height for the base of the counter trade, i.e. 4 Km. (13,000 ft.), is low, even for January as Table I indicates.

An examination of all 63 cases and of the ascents on the days immediately preceding and succeeding those on which strong easterlies were observed, revealed no tendency for the height of the counter trade to be consistently higher on days with strong easterlies than it was immediately before or after ; on some occasions it was actually lower. Moreover, the vertical structure of the counter trade, as revealed by balloons which had experienced a strong trade in the lower layers, was not apparently different from the normal. It is, consequently, a reasonable deduction that, in cases when no counter trade was observed, it was solely for the reason that the balloon was lost before reaching it and not because the upper wind structure in such cases was in any fundamental respect abnormal. It may, therefore, be considered that the loss of balloons at relatively low levels in strong winds does not invalidate the deductions which can be made from the available data regarding the upper wind regime over Jamaica.

Light westerlies in the lowest layers.—The wind roses indicate the existence of small percentages of westerly winds in the lowest layers at all seasons, but they do not show whether these winds are an extension downwards of the counter trade or whether they are due to some other cause. If they are not continuous with the counter trade they will be surmounted by the easterly trades, separating them from the westerly counter trades. Table IV has therefore been prepared to show at what height a light westerly wind (i.e. a light wind with a westerly component) in the lowest layers is replaced by an easterly current. Since on some occasions the easterly current was not reached, it has been necessary to include such cases in *italics* in the column indicating the height at which the balloon was lost. Apart from exceptional cases, which are discussed below, these winds (a certain percentage of which are included in the wind roses as winds of less than 3 m.p.h.) seldom extend above 1 Km. (3,000 ft.) and, in the early summer months May to July, rarely reach even this height.

These low westerlies usually blow from some point between WSW. and WNW. and are found immediately above the off-shore surface wind already discussed.

Exceptional Cases.—On several occasions westerly winds extended upwards from near the surface to 4 Km. (12,000 ft.) or higher, more frequently during the winter months November to March and, as it has been shewn that the counter trade often descends as low as this, it will be seen that on such occasions the trade wind may be completely absent at all heights. Such a complete reversal as this of the normal wind regime of the lower layers must be due to some major variation in the general circulation of the atmosphere in the vicinity of Jamaica, and it has already been suggested that a southward movement over the Gulf of Mexico of the polar front, and of the air behind it, might supply the key to these exceptional winds. Such a movement of the polar front as far south as Jamaica and the northers associated with it would be specifically winter phenomena. Some other explanation must, therefore, be sought for the occasions of high upward extension of low westerlies in summer, and as the major weather disturbances experienced in the Gulf of Mexico at that season are hurricanes or tropical revolving storms, it is likely that these are the cause.

The synoptic charts for all those occasions on which no trade wind was observed have been examined and the results are summarised in Table V. It was found that in most cases in winter the winds were from NW. or even from NNW. in the lower layers and were recorded as northers at Kingston. The reverse was not true ; several occasions have been recorded when the norther extended only about 1 kilometre and was surmounted by the trade wind. Before a norther appeared at Kingston the wind at Key West usually became N. or NW. and the temperature fell by an appreciable amount, occurrences which, in view of other confirmatory evidence, could be regarded as sufficient indication of the southward movement past Key West of the polar front. On the other hand, the number of cases where there was evidence of a fall in temperature at Kingston itself accompanying the change of wind was much smaller. This is no doubt due in part to the somewhat frequent absence of temperature data for Kingston on the charts consulted and also to the föhn effect which probably affects northerly winds there. The table shows the number of cases when the absence of the trade wind was associated with either

(1) an earlier fall of temperature at Key West (usually at least five degrees Fahrenheit), or

(2) a definite fall of temperature at Kingston, or

(3) the presence of a hurricane, generally to the north of Jamaica.

The figures in brackets in line (2) give the number of occasions on which temperature readings at Kingston were available(5).

TABLE V.—ANALYSIS OF CASES OF NO TRADE WIND ABOVE KINGSTON

W. or NW. wind accompanied by :—	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
(1) Fall of temperature at Key West.	2	7	6	..	..	..	..	..	..	..	3	2
(2) Fall of temperature at Kingston.	..	2 (6)	4 (7)	..	..	..	..	..	..	..	1 (2)	1 (2)
(3) Hurricane	..	..	..	..	..	..	..	1	2	3	4	..
Number of Cases ..	2	8	7	1	3	1	0	1	2	3	7	2

Note—Several consecutive days of W. or NW. winds apparently due to the same cause have been treated as one case.

It will be seen that, during the hurricane season (July–early November) such reversals of wind as were observed were accompanied by a hurricane to the north of Jamaica. During winter, however, it is practically certain from the evidence given here and from a careful examination of the synoptic charts that occasions when the trade was absent at all heights above Kingston were a result of the passage of the polar front south of Florida, associated with the movement of polar front depressions over or to the north of Florida. In several of these cases, on the other hand, it was very doubtful whether the front had actually passed Kingston. There remain, in addition, a number of cases, notably in April, May and June, when the polar front does not seem to have moved even as far south as Key West. The reversal of the wind on these occasions was found to be associated with the passage near Jamaica of shallow depressions not connected with the main polar front.

A diagram, from the article by Brooks(2) to which reference has already been made, is reproduced here (Fig. 7). It depicts the winds

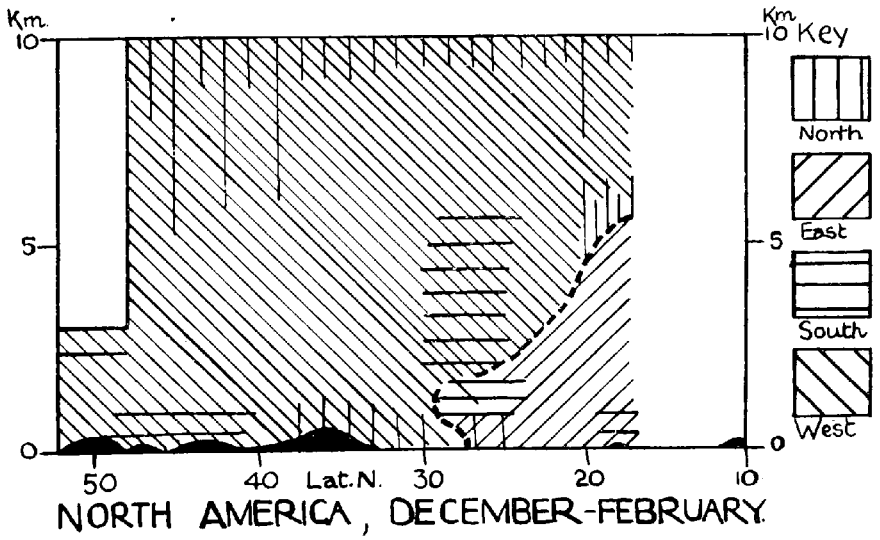

FIG. 7

above North America from December to February and shows the possible nature of the change occurring in such cases as that just discussed.

It will be seen that a southward movement of the surface of separation between easterlies and westerlies might bring Jamaica under the tongue of warm air shown over about 28° N. It would then have W. winds immediately above the surface, surmounted by a narrow belt of trades, above which westerly winds (the counter trade) would be again encountered. The above discussion has shown that this does in fact occur. A further southerly movement of the surface of separation would give westerly winds at all heights above Kingston. It is to be expected that, on days preceding a complete reversal of the easterly winds at all heights, the belt of trades above Kingston would become progressively shallower, due to the southerly movement of the surface of separation. This is actually revealed in a number of ascents.

Mean wind speeds.—Mean wind speeds have been calculated by Mr. Brennan for each month of the year for the eleven years covered by the records and these are given in Table VI.

These results are shown graphically in Fig. 8. The general characteristics of these curves are similar in all months, but an annual variation is apparent which corresponds to the annual oscillation of the boundary between trade and counter trade already discussed. From the surface the mean wind speed increases rapidly to a maximum at some height between 1·5 and 2·0 Km. (5,000 and 7,000 ft.) ; it is between these heights that the trade wind blows with greatest constancy at all periods of the year and where the surface deviations from the normal wind flow and the unusually low counter trades which have been examined above are least likely to be felt. This maximum mean wind speed has its highest value (25 m.p.h.) in July, when the constancy of the trade wind is at its maximum, and two low values in November (13 m.p.h.) and March (14 m.p.h.). It is during the winter months that the constancy of the trade is least, having its lowest value, viz. 69 per cent, in November as was shown in the paragraph on the trade and counter trade.

Above this level, 2 Km. (7,000 ft.) the mean wind speed decreases slowly to a minimum which varies in height and value throughout the year but which, it may be expected, will coincide with the average position of the transition zone between trade and counter trade, characterised by light winds usually from some northerly point. In view of the wide variations in the height at which this zone is found and the depth of the layer of transition, the low value of the rate of change of mean wind speed with height and the consequent wide variations in the height at which the lowest value is reached require no further explanation. As is to be expected, the transition zone of light winds is highest in the summer months

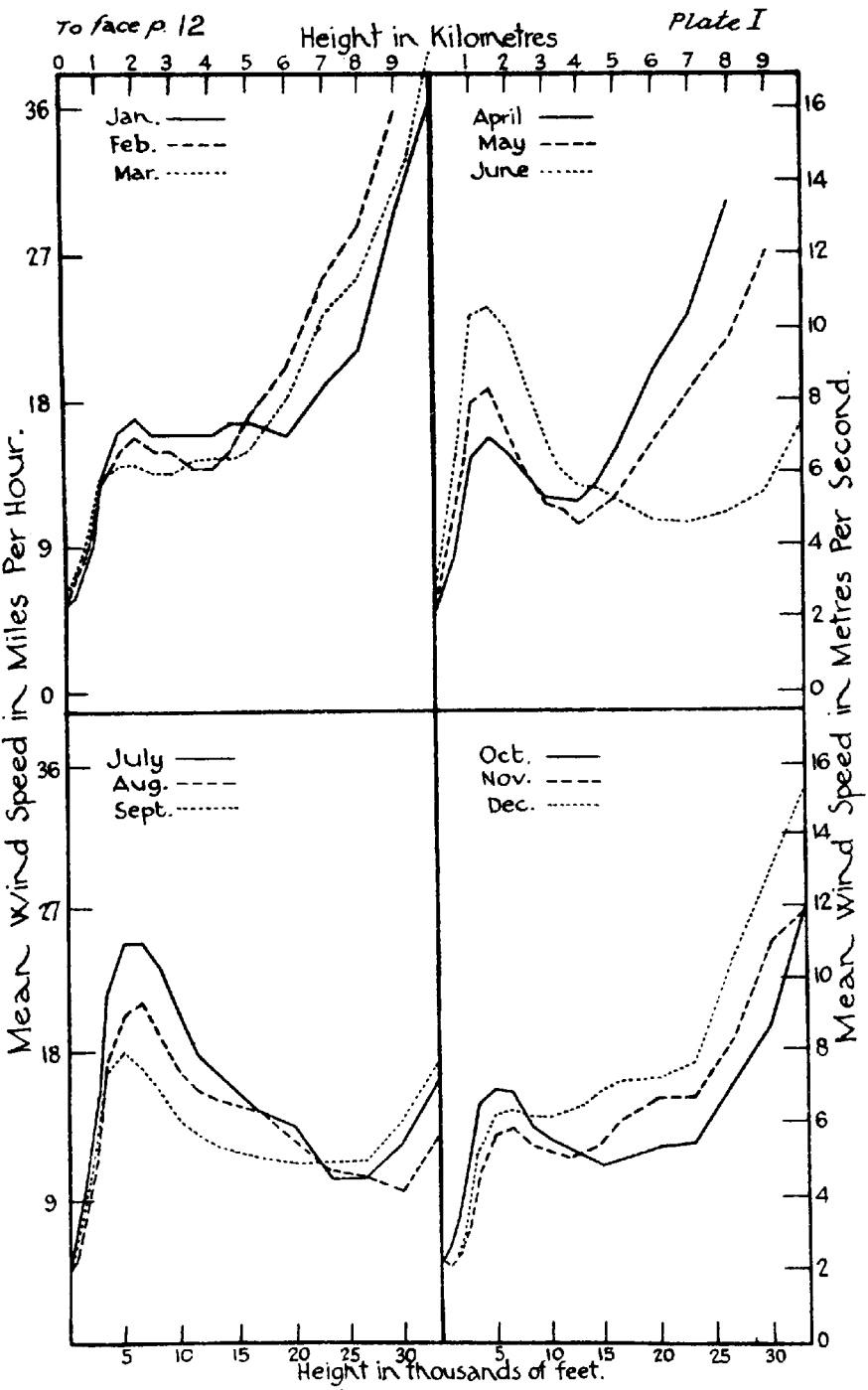

FIG. 8 MONTHLY MEAN WIND SPEEDS

TABLE VI.—MEAN WIND SPEED IN MILES PER HOUR AT VARIOUS HEIGHTS FOR EACH MONTH OF THE YEAR.

Height	Km.	0	0·25	0·5	0·75	1·0	1·5	2·0	2·5	3·0	3·5	4·0	4·5	5·0	6·0	7·0	8·0	9·0	10·0
	ft. × 10^3	0	0·8	1·7	2·5	3·3	5·0	6·7	8·3	10	12	13	15	17	20	23	27	30	33
January		5·2	5·6	7·2	8·8	13·1	16·0	16·9	16·0	16·0	16·0	16·0	16·6	16·6	16·0	18·9	21·2	29·5	36·4
February		5·0	6·1	7·7	9·2	12·6	14·6	15·8	15·1	15·1	14·0	14·0	15·1	16·9	20·0	15·7	28·6	35·5	..
March		5·2	6·7	8·3	10·1	13·1	14·0	14·2	13·5	13·5	14·2	14·4	14·4	15·1	18·2	23·2	25·6	30·8	39·4
April		4·7	6·5	8·3	10·8	14·4	15·8	14·8	13·1	11·9	11·7	11·7	12·6	14·9	19·8	23·2	30·2	..	..
May		5·0	7·4	10·6	13·5	17·8	18·7	16·2	13·5	11·7	11·3	10·4	11·0	11·9	15·3	18·7	21·8	27·0	..
June		5·2	9·9	13·7	17·8	23·4	23·8	22·5	19·1	16·0	13·7	12·8	12·4	11·9	10·6	10·3	11·0	12·4	16·4
July		4·5	7·2	11·0	15·1	21·6	24·8	24·8	23·2	20·5	17·8	16·7	15·5	14·4	13·3	10·1	10·3	12·2	16·0
August		4·3	5·4	8·5	12·4	17·1	20·3	21·2	18·9	16·9	15·5	15·1	14·7	14·4	12·4	10·3	10·1	9·5	12·6
September		4·5	6·7	9·9	12·6	16·6	18·0	17·1	15·3	13·7	12·8	11·9	11·7	11·5	11·0	11·0	11·2	13·7	17·4
October		4·5	5·9	7·9	10·6	14·4	15·5	15·3	13·3	12·4	11·9	11·5	10·8	11·2	11·9	12·2	16·0	19·4	26·8
November		5·0	4·7	5·4	7·0	10·3	12·0	13·1	11·9	11·7	11·5	11·7	12·2	13·5	15·1	15·1	18·6	24·7	26·8
December		5·2	4·7	5·6	7·2	11·5	14·0	14·2	14·0	14·0	14·2	14·6	15·5	16·0	16·2	17·3	23·6	29·0	34·2

June to September and lowest in the winter months, when apparently the change from trade to counter trade is on the average more abrupt.

The curves in Fig. 8 do not extend beyond the level of 10 Km. (33,000 ft.) and in every case the mean wind speed is still increasing with height there. It is during the winter months therefore, when the counter trade descends to its lowest, that the greatest values of the mean wind speed at 10 Km. (33,000 ft.) are encountered. The curves are not all completed up to this height (due to lack of sufficient data), but it seems that the average speed there is greater than 35 m.p.h. from December to April. An examination of individual ascents shows that such high speeds are encountered in the summer months also, but at greater heights.

In conclusion, reference may be made to some results obtained at San Juan, Puerto Rico (lat. 18° N., long. 66° W.) during the years 1926–31.(6.) San Juan occupies very much the same position as Kingston with regard to the trade wind belt ; it is, however, less subject to northers and is less likely to be affected by pressure changes on the continent of America. The off-shore breeze in the morning is from the south at this station. The results, as published, reveal much the same average structure of the upper winds as that found above Kingston, although little reference is made to the characteristics of individual ascents, the paper being concerned largely with resultant winds. On rare occasions westerly winds were observed at all heights above San Juan and it is probable that these were due to similar causes as have been shown to operate at Kingston in such circumstances.

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TABLE VII.—PERCENTAGE FREQUENCY OF SURFACE AND UPPER WINDS

JANUARY

Speed	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	SURFACE 0–3 m.p.h. 24. Total cases, 287.								0·5 Km. (1,500 feet) 0–3 m.p.h. 43. Total cases, 287.							
m.p.h.																
4–15	48	19	3	4	..	..	..	1	6	3	12	8	6	6	3	7
16–31 ..	1	..	..	..	..	..	..	..	1	..	2	3	..	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	49	19	3	4	..	..	..	1	7	3	14	11	6	6	3	7
	1 Km. (3,000 feet) 0–3 m.p.h. 28. Total cases, 285.								2 Km. (6,000 feet) 0–3 m.p.h. 5. Total cases, 277.							
m.p.h.																
4–15 ..	1	11	20	9	1	1	1	1	3	11	24	8	1	1	1	1
16–31 ..	1	1	20	4	..	..	..	..	..	2	31	7	..	..	..	..
32–47 ..	..	..	1	..	..	..	..	..	..	..	4	1	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	2	12	41	13	1	1	1	1	3	13	59	16	1	1	1	1
	3 Km. (10,000 feet) 0–3 m.p.h. 3. Total cases, 232.								4 Km. (13,000 feet) 0–3 m.p.h. 9. Total cases, 184.							
m.p.h.																
4–15 ..	4	11	24	12	1	2	2	1	5	15	13	8	3	3	4	4
16–31 ..	1	6	20	6	1	1	..	1	1	7	18	4	1	..	1	..
32–47 ..	..	1	3	..	..	..	..	..	..	1	2	..	..	..	1	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	5	18	47	18	2	3	2	2	6	23	33	12	4	3	6	4
	5 Km. (17,000 feet) 0–3 m.p.h. 3. Total cases, 148.								6 Km. (20,000 feet) 0–3 m.p.h. 2. Total cases, 129.							
m.p.h.																
4–15 ..	8	8	10	6	2	7	9	9	9	8	5	8	3	6	8	10
16–31 ..	2	8	10	5	1	2	4	2	7	7	7	2	3	4	4	3
32–47 ..	..	..	2	1	..	..	..	..	..	..	..	..	..	..	1	..
48 and over ..	..	1	..	..	..	..	..	..	..	2	1	..	..	..	..	..
TOTAL ..	10	17	22	12	3	9	13	11	16	17	13	10	6	10	13	13
	8 Km. (27,000 feet) 0–3 m.p.h. 3. Total cases, 68.								10 Km. (33,000 feet) 0–3 m.p.h. 0. Total cases, 41.							
m.p.h.																
4–15 ..	2	1	1	1	3	6	11	5	4	2	..	..	..	2	5	4
16–31 ..	3	3	2	..	2	10	17	11	2	..	..	..	..	6	25	10
32–47.. ..	2	1	..	..	..	4	6	3	..	..	..	..	..	4	10	4
48 and over ..	..	..	..	..	..	..	2	1	..	..	2	..	..	9	10	1
TOTAL ..	7	5	3	1	5	20	36	20	6	2	2	..	..	21	50	19

TABLE VIII.—PERCENTAGE FREQUENCY OF SURFACE AND UPPER WINDS

FEBRUARY

Speed	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	SURFACE 0–3 m.p.h. 28. Total cases, 261.								0·5 Km. (1,500 feet) 0–3 m.p.h. 43. Total cases, 261.							
m.p.h.																
4–15 ..	44	18	5	1	..	..	1	3	5	3	8	13	4	2	5	9
16–31 ..	..	..	..	..	..	..	..	..	1	..	3	3	..	..	..	1
32–47 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	44	18	5	1	..	..	1	3	6	3	11	16	4	2	5	10
	1 Km. (3,000 feet) 0–3 m.p.h. 24. Total cases, 261.								2 Km. (6,000 feet) 0–3 m.p.h. 4. Total cases, 251.							
m.p.h.																
4–15 ..	2	8	25	11	1	1	1	1	4	8	26	7	1	..	1	4
16–31 ..	1	..	17	6	..	..	..	1	..	3	27	9	..	..	1	..
32–47 ..	..	..	1	..	..	..	..	..	..	..	3	2	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	3	8	43	17	1	1	1	2	4	11	56	18	1	..	2	4
	3 Km. (10,000 feet) 0–3 m.p.h. 5. Total cases, 211.								4 Km. (13,000 feet) 0–3 m.p.h. 5. Total cases, 174.							
m.p.h.																
4–15 ..	4	10	18	10	2	2	4	2	4	13	16	7	4	6	8	5
16–31 ..	1	4	21	10	1	1	1	..	..	3	14	4	1	2	3	3
32–47 ..	..	..	2	1	..	..	1	..	..	..	1	..	..	..	1	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	5	14	41	21	3	3	6	2	4	16	31	11	5	8	12	8
	5 Km. (17,000 feet) 0–3 m.p.h. 2. Total cases, 146.								6 Km. (20,000 feet) 0–3 m.p.h. 2. Total cases, 124.							
m.p.h.																
4–15 ..	5	7	6	4	4	7	10	7	7	8	4	1	1	4	8	7
16–31 ..	2	6	10	6	1	2	11	4	2	5	6	4	2	3	17	8
32–47 ..	..	..	1	1	1	1	1	1	1	2	1	1	1	1	3	1
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	7	13	17	11	6	10	22	12	10	15	11	6	4	8	28	16
	8 Km. (27,000 feet) 0–3 m.p.h. 1. Total cases, 70.								10 Km. (33,000 feet) 0–3 m.p.h. 4. Total cases, 27.							
m.p.h.																
4–15 ..	4	6	3	3	1	2	4	6	7	2	..	..	4	..	4	6
16–31 ..	2	1	1	3	1	6	13	7	4	..	4	..	..	7	5	5
32–47 ..	4	..	..	1	2	4	10	7	2	..	..	..	..	2	15	11
48 and over ..	1	..	..	..	..	..	6	1	2	..	..	..	..	2	7	7
TOTAL ..	11	7	4	7	4	12	33	21	15	2	4	..	4	11	31	29

TABLE IX.—PERCENTAGE FREQUENCY OF SURFACE AND UPPER WINDS

MARCH

Speed	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	SURFACE 0–3 m.p.h. 31. Total cases, 298.								0·5 Km. (1,500 feet) 0–3 m.p.h. 39. Total cases, 295.							
m.p.h.																
4–15 ..	43	18	2	3	..	..	1	..	6	2	8	17	4	3	3	6
16–31 ..	1	..	..	1	..	..	..	..	1	..	2	7	..	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	44	18	2	4	..	..	1	..	7	2	11	25	4	3	3	6
	1 Km. (3,000 feet) 0–3 m.p.h. 26. Total cases, 294.								2 Km. (6,000 feet) 0–3 m.p.h. 7. Total cases, 272.							
m.p.h.																
4–15 ..	2	6	19	7	2	2	2	2	2	7	27	9	3	4	2	1
16–31 ..	..	..	18	11	..	..	..	..	..	2	24	9	..	..	..	..
32–47 ..	..	..	1	2	..	..	..	..	..	..	3	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	2	6	38	20	2	2	2	2	2	9	54	18	3	4	2	1
	3 Km. (10,000 feet) 0–3 m.p.h. 7. Total cases, 230.								4 Km. (13,000 feet) 0–3 m.p.h. 5. Total cases, 186.							
m.p.h.																
4–15 ..	3	14	17	12	4	3	3	3	11	12	12	5	2	5	9	6
16–31 ..	1	3	14	7	1	1	1	2	2	8	6	3	1	3	3	3
32–47 ..	..	1	1	1	..	..	1	..	..	..	1	1	..	1	1	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	4	18	32	20	5	4	5	5	13	20	19	9	3	9	13	9
	5 Km. (17,000 feet) 0–3 m.p.h. 5. Total cases, 144.								6 Km. (20,000 feet) 0–3 m.p.h. 3. Total cases, 118.							
m.p.h.																
4–15 ..	10	10	8	3	2	6	8	12	8	5	4	2	1	6	9	14
16–31 ..	4	5	3	2	1	5	8	5	8	3	4	1	..	3	11	11
32–47 ..	..	1	..	..	..	..	1	1	2	1	..	..	..	1	1	2
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	14	16	11	5	3	11	17	18	18	9	8	3	1	10	21	27
	8 Km. (27,000 feet) 0–3 m.p.h. 2. Total cases, 64.								10 Km. (33,000 feet) 0–3 m.p.h. 0. Total cases, 21.							
m.p.h.																
4–15 ..	..	..	..	..	..	5	5	6	..	..	..	..	..	..	..	5
16–31 ..	7	4	..	..	..	3	22	22	..	..	..	..	..	..	29	10
32–47 ..	2	..	..	..	..	2	15	5	..	..	..	..	..	2	21	10
48 and over ..	..	..	..	..	..	..	..	..	2	..	..	..	..	2	17	2
TOTAL ..	9	4	..	..	..	10	42	33	2	..	..	..	..	4	67	27

TABLE X.—PERCENTAGE FREQUENCY OF SURFACE AND UPPER WINDS

APRIL

Speed	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	SURFACE 0–3 m.p.h. 31. Total cases, 264.								0·5 Km. (1,500 feet) 0–3 m.p.h. 34. Total cases, 263.							
m.p.h.																
4–15 ..	45	13	2	6	..	..	1	2	3	1	11	27	3	1	2	8
16–31 ..	..	..	..	..	..	..	..	..	..	..	3	7	..	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	45	13	2	6	..	..	1	2	3	1	14	34	3	1	2	8
	1 Km. (3,000 feet) 0–3 m.p.h. 15. Total cases, 261.								2 Km. (6,000 feet) 0–3 m.p.h. 4. Total cases, 248.							
m.p.h.																
4–15 ..	1	3	25	13	1	1	1	2	1	9	27	13	3	1	..	..
16–31 ..	..	..	26	12	..	..	..	..	..	2	25	12	..	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	..	2	1	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	1	3	51	25	1	1	1	2	1	11	54	26	3	1	..	..
	3 Km. (10,000 feet) 0–3 m.p.h. 5. Total cases, 218.								4 Km. (13,000 feet) 0–3 m.p.h. 7. Total cases, 160.							
m.p.h.																
4–15 ..	3	9	23	17	8	5	3	2	6	12	7	8	11	9	11	6
16–31 ..	1	3	16	4	..	1	..	..	1	5	4	2	1	4	3	2
32–47 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..
TOTAL ..	4	12	39	21	8	6	3	2	7	17	12	10	12	13	14	8
	5 Km. (17,000 feet) 0–3 m.p.h. 7. Total cases, 131.								6 Km. (20,000 feet) 0–3 m.p.h. 0. Total cases, 111.							
m.p.h.																
4–15 ..	8	5	4	2	3	15	14	8	9	3	2	1	2	8	10	6
16–31 ..	2	4	2	..	1	4	11	3	5	3	1	..	2	13	20	8
32–47 ..	2	..	..	..	1	..	1	3	1	..	..	..	..	..	2	3
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
TOTAL ..	12	9	6	2	5	19	26	14	15	6	3	1	4	21	32	18
	8 Km. (27,000 feet) 0–3 m.p.h. 0. Total cases, 60.								10 Km. (33,000 feet) 0–3 m.p.h. 0. Total cases, 25.							
m.p.h.																
4–15 ..	4	2	1	2	..	1	5	6	..	..	2	2	..	4	4	..
16–31 ..	5	..	..	..	..	7	30	5	..	..	..	4	..	2	12	14
32–47 ..	1	..	..	..	..	3	15	7	..	..	..	..	..	2	26	4
48 and over ..	..	..	..	..	..	1	2	3	..	..	..	..	..	6	14	4
TOTAL ..	10	2	1	2	..	12	52	21	..	..	2	6	..	14	56	22

TABLE XI.—PERCENTAGE FREQUENCY OF SURFACE AND UPPER WINDS

MAY

Speed	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	Surface 0–3 m.p.h. 27. Total cases, 303.								0·5 Km. (1,500 feet) 0–3 m.p.h. 32. Total cases, 303.							
m.p.h.																
4–15 ..	41	16	3	8	..	1	..	3	3	2	13	28	2	..	2	5
16–31 ..	..	..	1	..	..	..	..	..	..	..	1	12	..	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	41	16	4	8	..	1	..	3	3	2	14	40	2	..	2	5
	1 Km. (3,000 feet) 0–3 m.p.h. 11. Total cases, 302.								2 Km. (6,000 feet) 0–3 m.p.h. 3. Total cases, 290.							
m.p.h.																
4–15 ..	..	2	20	9	2	1	..	..	1	2	19	14	2	1	1	1
16–31 ..	..	..	37	15	..	..	..	..	..	1	28	19	1	1	..	..
32–47 ..	..	..	1	2	..	..	..	..	..	..	3	3	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	..	2	58	26	2	1	..	..	1	3	50	36	3	2	1	1
	3 Km. (10,000 feet) 0–3 m.p.h. 2. Total cases, 249.								4 Km. (13,000 feet) 0–3 m.p.h. 11. Total cases, 200.							
m.p.h.																
4–15 ..	2	6	23	25	9	3	1	4	2	8	15	15	12	9	7	4
16–31 ..	..	1	9	7	4	2	..	..	1	1	3	2	1	2	4	1
32–47 ..	..	..	..	..	1	1	..	..	..	..	..	1	..	1	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	2	7	32	32	14	6	1	4	3	9	18	18	13	12	11	5
	5 Km. (17,000 feet) 0–3 m.p.h. 5. Total cases, 158.								6 Km. (20,000 feet) 0–3 m.p.h. 7. Total cases, 136.							
m.p.h.																
4–15 ..	8	10	9	6	5	12	15	11	6	7	3	2	5	7	19	13
16–31 ..	1	1	3	1	1	3	5	3	1	4	5	..	..	4	8	7
32–47 ..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	1	1
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	9	11	12	7	6	16	20	14	7	11	8	2	5	11	28	21
	8 Km. (27,000 feet) 0–3 m.p.h. 0. Total cases, 89.								10 Km. (33,000 feet) 0–3 m.p.h. 0. Total cases, 48.							
m.p.h.																
4–15 ..	5	4	2	1	1	3	10	12	4	1	..	..	..	1	6	4
16–31 ..	11	2	1	..	1	4	17	16	6	..	..	..	..	..	12	16
32–47 ..	..	..	..	..	..	..	3	5	3	1	..	..	..	3	16	15
48 and over ..	..	..	..	..	..	..	..	2	2	..	..	..	..	..	6	4
TOTAL ..	16	6	3	1	2	7	30	35	15	2	..	..	..	4	40	39

TABLE XII.—PERCENTAGE FREQUENCY OF SURFACE AND UPPER WINDS

JUNE

Speed	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	Surface 0–3 m.p.h. 24. Total cases, 285.								0·5 Km. (1,500 feet) 0–3 m.p.h. 25. Total cases, 284.							
m.p.h.																
4–15 ..	43	14	4	12	..	..	..	2	2	..	19	24	1	..	2	6
16–31 ..	..	..	..	1	..	..	..	..	..	..	9	12	..	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	43	14	4	13	..	..	..	2	2	..	28	36	1	..	2	6
	1 Km. (3,000 feet) 0–3 m.p.h. 4. Total cases, 284.								2 Km. (6,000 feet) 0–3 m.p.h. 1. Total cases, 269.							
m.p.h.																
4–15 ..	..	..	16	4	1	..	..	..	..	3	8	5	2	1	..	..
16–31 ..	..	..	52	18	..	..	..	..	..	..	37	28	..	..	..	..
32–47 ..	..	..	4	1	..	..	..	..	..	..	9	6	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	..	..	72	23	1	..	..	..	..	3	54	39	2	1	..	..
	3 Km. (10,000 feet) 0–3 m.p.h. 2. Total cases, 213.								4 Km. (13,000 feet) 0–3 m.p.h. 4. Total cases, 154.							
m.p.h.																
4–15 ..	..	3	16	24	4	2	1	..	1	8	28	20	8	3	1	2
16–31 ..	..	1	21	20	1	1	..	..	..	4	11	6	2	1	1	..
32–47 ..	..	..	3	1	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	..	4	40	45	5	3	1	..	1	12	39	26	10	4	2	2
	5 Km. (17,000 feet) 0–3 m.p.h. 6. Total cases, 114.								6 Km. (20,000 feet) 0–3 m.p.h. 8. Total cases, 94.							
m.p.h.																
4–15 ..	4	14	29	11	6	5	5	3	7	13	16	10	11	4	10	7
16–31 ..	..	1	5	6	3	1	..	..	2	4	2	2	1	2	..	..
32–47 ..	..	..	..	..	..	1	..	..	..	..	..	1	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	4	15	34	17	9	7	5	3	9	17	18	13	12	6	10	7
	8 Km. (27,000 feet) 0–3 m.p.h. 6. Total cases, 64.								10 Km. (33,000 feet) 0–3 m.p.h. 3. Total cases, 35.							
m.p.h.																
4–15 ..	9	10	11	8	3	5	12	9	4	11	8	..	3	3	7	5
16–31 ..	9	6	1	2	..	2	2	5	9	4	3	..	..	..	13	20
32–47 ..	..	..	..	..	..	..	..	..	4	..	..	..	..	..	..	3
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	18	16	12	10	3	7	14	14	17	15	11	..	3	3	20	28

TABLE XIII.—PERCENTAGE FREQUENCY OF SURFACE AND UPPER WINDS

JULY

Speed	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	SURFACE 0–3 m.p.h. 26. Total cases, 290.								0·5 Km. (1,500 feet) 0–3 m.p.h. 33. Total cases, 290.							
m.p.h.																
4–15 ..	52	13	5	1	..	..	2	..	3	3	21	17	1	..	5	6
16–31 ..	..	..	..	1	..	..	..	..	..	..	6	4	..	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	52	13	5	2	..	..	2	..	3	3	27	22	1	..	5	6
	1 Km. (3,000 feet) 0–3 m.p.h. 6. Total cases, 289.								2 Km. (6,000 feet) 0–3 m.p.h. 1. Total cases, 281.							
m.p.h.																
4–15 ..	..	1	25	4	..	..	..	1	..	2	7	2	..	..	..	..
16–31 ..	..	..	50	6	..	..	..	..	..	1	49	16	..	..	..	..
32–47 ..	..	..	5	2	..	..	..	..	..	..	17	5	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	..	1	80	12	..	..	..	1	..	3	73	23	..	..	..	..
	3 Km. (10,000 feet) 0–3 m.p.h. 1. Total cases, 239.								4 Km. (13,000 feet) 0–3 m.p.h. 3. Total cases, 167.							
m.p.h.																
4–15 ..	1	3	19	8	..	..	..	..	1	7	28	18	1	..	..	1
16–31 ..	..	1	34	19	1	..	..	..	..	3	25	9	1	..	..	..
32–47 ..	..	1	7	5	..	..	..	..	..	1	1	1	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	1	5	60	32	1	..	..	..	1	11	54	28	2	..	..	1
	5 Km. (17,000 feet) 0–3 m.p.h. 6. Total cases, 118.								6 Km. (20,000 feet) 0–3 m.p.h. 3. Total cases, 90.							
m.p.h.																
4–15	3	4	30	19	4	..	1	1	6	12	20	21	9	2	2	4
16–31 ..	1	4	17	7	1	..	..	..	1	3	8	6	1	..	..	..
32–47 ..	..	..	1	1	..	..	..	..	..	..	1	1	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	4	8	48	27	5	..	1	1	7	15	29	28	10	2	2	4
	8 Km. (27,000 feet) 0–3 m.p.h. 6. Total cases, 48.								10 Km. (33,000 feet) 0–3 m.p.h. 4. Total cases, 26.							
m.p.h.																
4–15 ..	10	12	13	6	10	6	10	12	13	4	4	6	8	2	4	6
16–31 ..	5	3	1	2	..	1	1	1	15	7	2	..	..	4	4	9
32–47 ..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4
48 and over ..	..	..	..	..	..	..	..	..	2	2	..	..	..	..	..	..
TOTAL ..	16	15	14	8	10	7	11	13	30	13	6	6	8	6	8	19

TABLE XIV.—PERCENTAGE FREQUENCY OF SURFACE AND UPPER WINDS

AUGUST

Speed	N.	NE.	E.	SE.	S.	SW.	W.	NW	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	SURFACE 0–3 m.p.h. 31. Total cases, 299.								0·5 Km. (1,500 feet) 0–3 m.p.h. 43. Total cases, 299.							
m.p.h.																
4–15 ..	47	17	1	3	..	..	..	1	4	4	15	19	1	2	4	5
16–31 ..	..	..	..	..	..	..	..	..	..	..	..	3	..	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	47	17	1	3	..	..	..	1	4	4	15	22	1	2	4	5
	1 Km. (3,000 feet) 0–3 m.p.h. 11. Total cases, 299.								2 Km. (6,000 feet) 0–3 m.p.h. 1. Total cases, 294.							
m.p.h.																
4–15 ..	1	3	23	5	1	1	..	2	..	5	14	4	1	..	..	..
16–31 ..	..	..	43	8	..	..	..	..	..	2	48	14	..	..	..	..
32–47 ..	..	..	2	..	..	..	..	..	..	..	8	2	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..
TOTAL ..	1	3	68	13	1	1	..	2	..	7	71	20	1	..	..	..
	3 Km. (10,000 feet) 0–3 m.p.h. 0. Total cases, 262.								4 Km. (13,000 feet) 0–3 m.p.h. 3. Total cases, 203.							
m.p.h.																
4–15 ..	..	5	21	15	2	..	..	..	1	8	31	13	4	..	..	1
16–31 ..	..	3	31	16	..	..	..	..	1	6	25	7	..	..	..	..
32–47 ..	..	..	6	1	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	..	8	58	32	2	..	..	..	2	14	56	20	4	..	..	1
	5 Km. (17,000 feet) 0–3 m.p.h. 3. Total cases, 163.								6 Km. (20,000 feet) 0–3 m.p.h. 5. Total cases, 131.							
m.p.h.																
4–15 ..	2	14	27	11	4	1	1	1	2	14	27	13	7	2	2	2
16–31 ..	..	6	21	6	2	..	1	..	1	4	13	6	1	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	2	20	48	17	6	1	2	1	3	19	40	19	8	2	2	2
	8 Km. (27,000 feet) 0–3 m.p.h. 8. Total cases, 75.								10 Km. (33,000 feet) 0–3 m.p.h. 8. Total cases, 37.							
m.p.h.																
4–15 ..	13	9	17	12	8	10	9	5	7	9	3	12	5	7	18	7
16–31 ..	1	2	4	1	..	1	..	..	..	7	8	1	..	..	5	3
32–47 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	14	11	21	13	8	11	9	5	7	16	11	13	5	7	23	10

TABLE XV.—PERCENTAGE FREQUENCY OF SURFACE AND UPPER WINDS

SEPTEMBER

Speed	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	SURFACE. 0–3 m.p.h. 38. Total cases, 285.								0·5 Km. (1,500 feet) 0–3 m.p.h. 34. Total cases, 285.							
m.p.h.																
4–15 ..	40	15	3	3	..	..	1	..	3	2	13	27	3	..	5	6
16–31 ..	..	..	..	..	..	..	..	..	..	..	..	7	..	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	40	15	3	3	..	..	1	..	3	2	13	34	3	..	5	6
	1 Km. (3,000 feet) 0–3 m.p.h. 11. Total cases, 283.								2 Km. (6,000 feet) 0–3 m.p.h. 4. Total cases, 272.							
m.p.h.																
4–15 ..	..	2	18	13	2	1	2	2	1	5	21	13	2	1	..	..
16–31 ..	..	..	31	15	..	..	..	..	..	..	28	18	1	..	..	..
32–47 ..	..	..	2	1	..	..	..	..	..	..	3	3	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	..	2	51	29	2	1	2	2	1	5	52	34	3	1	..	..
	3 Km. (10,000 feet) 0–3 m.p.h. 3. Total cases, 243.								4 Km. (13,000 feet) 0–3 m.p.h. 8. Total cases, 184.							
m.p.h.																
4–15 ..	..	8	24	19	4	2	..	..	4	11	29	20	5	3	2	1
16–31 ..	..	1	20	15	2	1	..	..	..	2	11	4	..	..	..	..
32–47 ..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	..	9	45	34	6	3	..	..	4	13	40	24	5	3	2	1
	5 Km. (17,000 feet) 0–3 m.p.h. 7. Total cases, 154.								6 Km. (20,000 feet) 0–3 m.p.h. 6. Total cases, 126.							
m.p.h.																
4–15 ..	4	16	23	11	7	4	3	4	9	19	20	13	7	4	6	5
16–31 ..	..	3	8	6	3	..	..	..	1	4	4	2	..	..	..	..
32–47 ..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	4	19	32	17	10	4	3	4	10	23	24	15	7	4	6	5
	8 Km. (27,000 feet) 0–3 m.p.h. 6. Total cases, 67.								10 Km. (33,000 feet) 0–3 m.p.h. 0. Total cases, 31.							
m.p.h.																
4–15 ..	12	10	7	11	5	6	11	8	8	5	8	..	2	2	13	11
16–31 ..	4	9	3	2	1	1	..	..	10	14	2	..	..	1	6	1
32–47 ..	2	2	..	..	..	..	..	..	6	2	5	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	2	2	..	..	..	..	..	..
TOTAL ..	18	21	10	13	6	7	11	8	26	23	15	..	2	3	19	12

TABLE XVI.—PERCENTAGE FREQUENCY OF SURFACE AND UPPER WINDS

OCTOBER

Speed	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	SURFACE. 0–3 m.p.h. 37. Total cases, 278.								0·5 Km. (1,500 feet) 0–3 m.p.h. 44. Total cases, 278.							
m.p.h.																
4–15 ..	44	12	2	4	1	..	..	..	3	2	8	23	2	2	3	5
16–31 ..	..	..	..	..	..	..	..	..	..	..	3	5	..	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	44	12	2	4	1	..	..	..	3	2	11	28	2	2	3	5
	1 Km. (3,000 feet) 0–3 m.p.h. 18. Total cases, 276.								2 Km. (6,000 feet) 0–3 m.p.h. 5. Total cases, 265.							
m.p.h.																
4–15 ..	1	1	25	16	3	..	2	1	..	7	25	10	3	..	1	..
16–31 ..	..	..	23	9	..	..	..	..	..	..	26	19	1	..	..	..
32–47 ..	..	..	1	..	..	..	..	..	..	..	3	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	1	1	49	25	3	..	2	1	..	7	54	29	4	..	1	..
	3 Km. (10,000 feet) 0–3 m.p.h. 4. Total cases, 226.								4 Km. (13,000 feet) 0–3 m.p.h. 7. Total cases, 190.							
m.p.h.																
4–15 ..	3	9	28	20	4	2	1	1	3	12	23	18	7	4	3	2
16–31 ..	..	1	19	6	..	..	1	..	1	4	11	4	1	..	..	..
32–47 ..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	3	10	47	27	4	2	2	1	4	16	34	22	8	4	3	2
	5 Km. (17,000 feet) 0–3 m.p.h. 9. Total cases, 149.								6 Km. (20,000 feet) 0–3 m.p.h. 10. Total cases, 124.							
m.p.h.																
4–15 ..	7	17	17	16	6	4	4	6	8	19	17	10	7	5	3	5
16–31 ..	..	5	6	..	..	1	..	..	..	4	6	1	1	..	1	..
32–47 ..	..	1	..	..	..	..	..	..	..	1	..	..	..	1	..	..
48 and over ..	..	..	1	..	..	..	..	..	..	1	..	..	..	..	..	..
TOTAL ..	7	23	24	16	6	5	4	6	8	25	23	11	8	6	4	5
	8 Km. (27,000 feet) 0–3 m.p.h. 4. Total cases, 67.								10 Km. (33,000 feet) 0–3 m.p.h. 9. Total cases, 35.							
m.p.h.																
4–15 ..	13	13	4	10	4	4	7	10	10	6	3	1	4	7	10	7
16–31 ..	3	9	4	1	1	2	2	4	7	6	6	..	6	..	6	4
32–47 ..	1	2	..	..	..	..	..	2	..	3	..	..	..	..	1	1
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3
TOTAL ..	17	24	8	11	5	6	9	16	17	15	9	1	10	7	17	15

TABLE XVII.—PERCENTAGE FREQUENCY OF SURFACE AND UPPER WINDS

NOVEMBER

Speed	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	SURFACE 0–3 m.p.h. 30. Total cases, 283.								0·5 Km. (1,500 feet) 0–3 m.p.h. 44. Total cases, 282.							
m.p.h.																
4–15 ..	51	15	2	1	..	..	..	1	7	3	4	15	6	4	6	7
16–31 ..	..	..	..	..	..	..	..	..	1	..	1	2	..	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	51	15	2	1	..	..	..	1	8	3	5	17	6	4	6	7
	1 Km. (3,000 feet) 0–3 m.p.h. 23. Total cases, 280.								2 Km. (6,000 feet) 0–3 m.p.h. 6. Total cases, 271.							
m.p.h.																
4–15 ..	3	14	25	10	1	..	4	3	3	9	31	10	2	1	2	1
16–31 ..	..	2	10	4	..	..	1	..	..	6	23	4	1	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	3	16	35	14	1	..	5	3	3	15	55	14	3	1	2	1
	3 Km. (10,000 feet) 0–3 m.p.h. 7. Total cases, 243.								4 Km. (13,000 feet) 0–3 m.p.h. 7. Total cases, 198.							
m.p.h.																
4–15 ..	3	20	29	10	3	1	3	1	8	22	20	6	4	4	3	4
16–31 ..	1	3	14	1	..	1	2	..	1	7	10	2	..	1	..	..
32–47 ..	..	..	..	1	..	..	..	..	..	..	1	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	4	23	43	12	3	2	5	1	9	29	31	8	4	5	3	4
	5 Km. (17,000 feet) 0–3 m.p.h. 8. Total cases, 159.								6 Km. (20,000 feet) 0–3 m.p.h. 4. Total cases, 133.							
m.p.h.																
4–15 ..	11	13	13	8	3	3	7	6	8	11	8	6	3	7	8	6
16–31 ..	4	6	7	1	1	2	1	2	9	9	7	1	1	3	3	3
32–47 ..	1	2	1	..	..	..	..	..	..	2	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..
TOTAL ..	16	21	21	9	4	5	8	8	17	23	15	7	4	10	11	9
	8 Km. (27,000 feet) 0–3 m.p.h. 1. Total cases, 70.								10 Km. (33,000 feet) 0–3 m.p.h. 3. Total cases, 40.							
m.p.h.																
4–15 ..	5	3	6	8	4	6	9	4	1	1	..	4	6	5	7	3
16–31 ..	10	3	..	1	1	9	7	9	4	3	..	..	1	13	20	7
32–47 ..	4	4	1	..	..	1	2	2	..	..	..	..	..	..	10	5
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	5
TOTAL ..	19	10	7	9	5	16	18	15	5	4	..	4	7	20	37	20

TABLE XVIII.—PERCENTAGE FREQUENCY OF SURFACE AND UPPER WINDS

DECEMBER

Speed	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	SURFACE 0–3 m.p.h. 27. Total cases, 305.								0·5 Km. (1,500 feet) 0–3 m.p.h. 45. Total cases, 305.							
m.p.h.																
4–15 ..	50	17	3	2	..	..	..	1	6	4	7	11	8	4	5	8
16–31 ..	..	..	..	..	..	..	..	..	1	..	..	1	..	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	50	17	3	2	..	..	..	1	7	4	7	12	8	4	5	8
	1 Km. (3,000 feet) 0–3 m.p.h. 30. Total cases, 305.								2 Km. (6,000 feet) 0–3 m.p.h. 7. Total cases, 296.							
m.p.h.																
4–15 ..	2	11	23	9	1	2	1	1	3	8	23	10	1	1	..	3
16–31 ..	..	..	18	2	..	..	..	..	..	4	28	7	..	..	..	..
32–47 ..	..	..	..	..	..	..	..	..	..	..	4	1	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	2	11	41	11	1	2	1	1	3	12	55	18	1	1	..	3
	3 Km. (10,000 feet) 0–3 m.p.h. 6. Total cases, 267.								4 Km. (13,000 feet) 0–3 m.p.h. 4. Total cases, 219.							
m.p.h.																
4–15 ..	6	10	22	6	4	3	1	3	3	13	19	9	3	2	3	4
16–31 ..	..	5	22	9	..	..	1	..	2	9	19	6	..	1	1	..
32–47 ..	..	..	2	..	..	..	..	..	..	1	1	..	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	6	15	46	15	4	3	2	3	5	23	39	15	3	3	4	4
	5 Km. (17,000 feet) 0–3 m.p.h. 5. Total cases, 176.								6 Km. (20,000 feet) 0–3 m.p.h. 5. Total cases, 142.							
m.p.h.																
4–15 ..	6	9	10	8	5	3	4	4	6	8	8	6	2	3	5	8
16–31 ..	1	9	17	7	1	2	3	1	2	9	17	7	2	3	4	3
32–47 ..	1	1	2	1	..	..	..	..	..	1	..	1	..	..	..	..
48 and over ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL ..	8	19	29	16	6	5	7	5	8	18	25	14	4	6	9	11
	8 Km. (27,000 feet) 0–3 m.p.h. 1. Total cases, 78.								10 Km. (33,000 feet) 0–3 m.p.h. 0. Total cases, 40.							
m.p.h.																
4–15 ..	6	2	6	6	5	5	8	6	..	..	..	..	..	3	3	10
16–31 ..	4	8	1	1	1	8	13	8	4	4	3	..	3	11	20	3
32–47 ..	1	2	1	..	..	2	3	1	2	..	..	..	..	5	9	3
48 and over ..	..	..	..	..	..	..	1	..	..	..	..	..	..	5	12	..
TOTAL ..	11	12	8	7	6	15	25	15	6	4	3	..	3	24	44	16

(37384) Wt. 490/363 625 10/37 Hw. G.371

S.O. Code No. 40–57–78

Professional Notes No.80.

Addendum.

The following method of procedure, suggested by F/Lt.D.W.Johnston, is now recommended in place of that described in paragraph (5) page 3. It eliminates the relatively large error when $T_o - T$ is large, discussed in paragraph (6).
Let T_o, p_o be values of temperature and pressure at sea level; let T_1, p_1, ; T_2, p_2 etc. be values at the points of observation, and let h_1, h_2 be the corresponding heights to be determined.

(1) Set pressure scale to p_o, and temperature index to the value $\frac{1}{2}(T_o + T_1)$. Set cursor line to p_1; read off h_1 on the height scale.

(2) Set temperature index to the value $\frac{1}{2}(T_1 + T_2)$; move pressure scale and cursor together until the value h_1 on the height scale is again under the cursor line; move cursor to reading p_2; read the height scale to obtain h_2 (This operation is equivalent to computing the thickness of the layer between p_1 and p_2 and adding it mechanically to the height of p_1).

(3) Proceed step by step in a similar manner, reading off the values of h_3, h_4 etc. in succession. When the mean temperature of the layer falls to 0^oF change over to the low-range scales (para (10)) and adopt the last pressure level as a new datum from which to reckon heights; add the height of the datum level to the computed heights in order to obtain height above M.S.L.

28.11.41. E.G.Bilham.

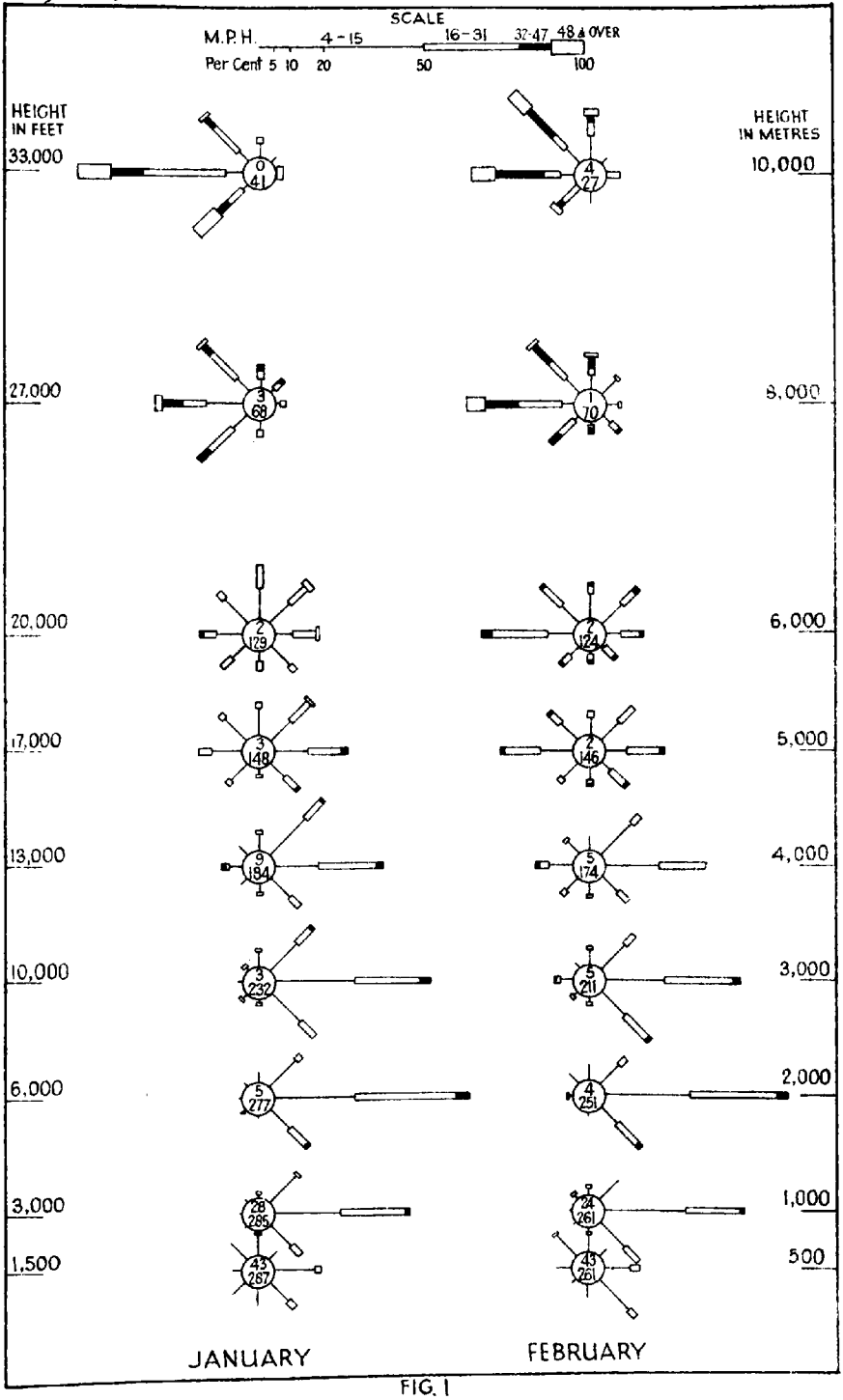

FIG. 1

(3100) W.t 490A 625 9'37, 6p 921C&RL.T*

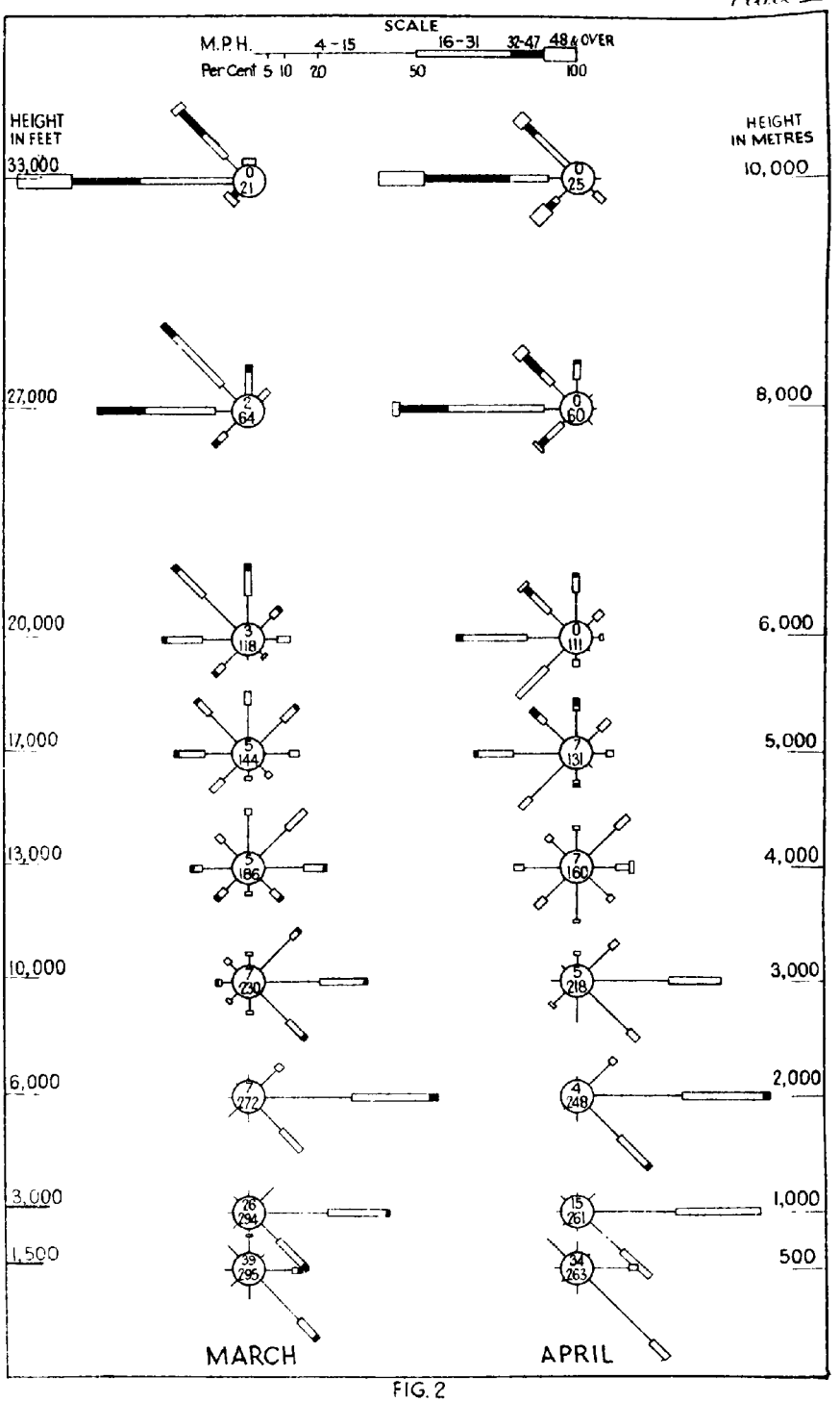
SCALE
M.P.H. 4-15 16-31 32-47 48 & OVER
Per Cent 5 10 20 50 100
HEIGHT IN FEET
HEIGHT IN METRES
33,000
10,000
27,000
8,000
20,000
6,000
17,000
5,000
13,000
4,000
10,000
3,000
6,000
2,000
3,000
1,000
1,500
500
0 21
0 25
2 64
0 60
3 118
0 111
5 144
7 131
5 186
7 160
7 230
5 218
7 272
4 248
26 294
15 261
39 295
34 263
MARCH
APRIL

FIG. 2

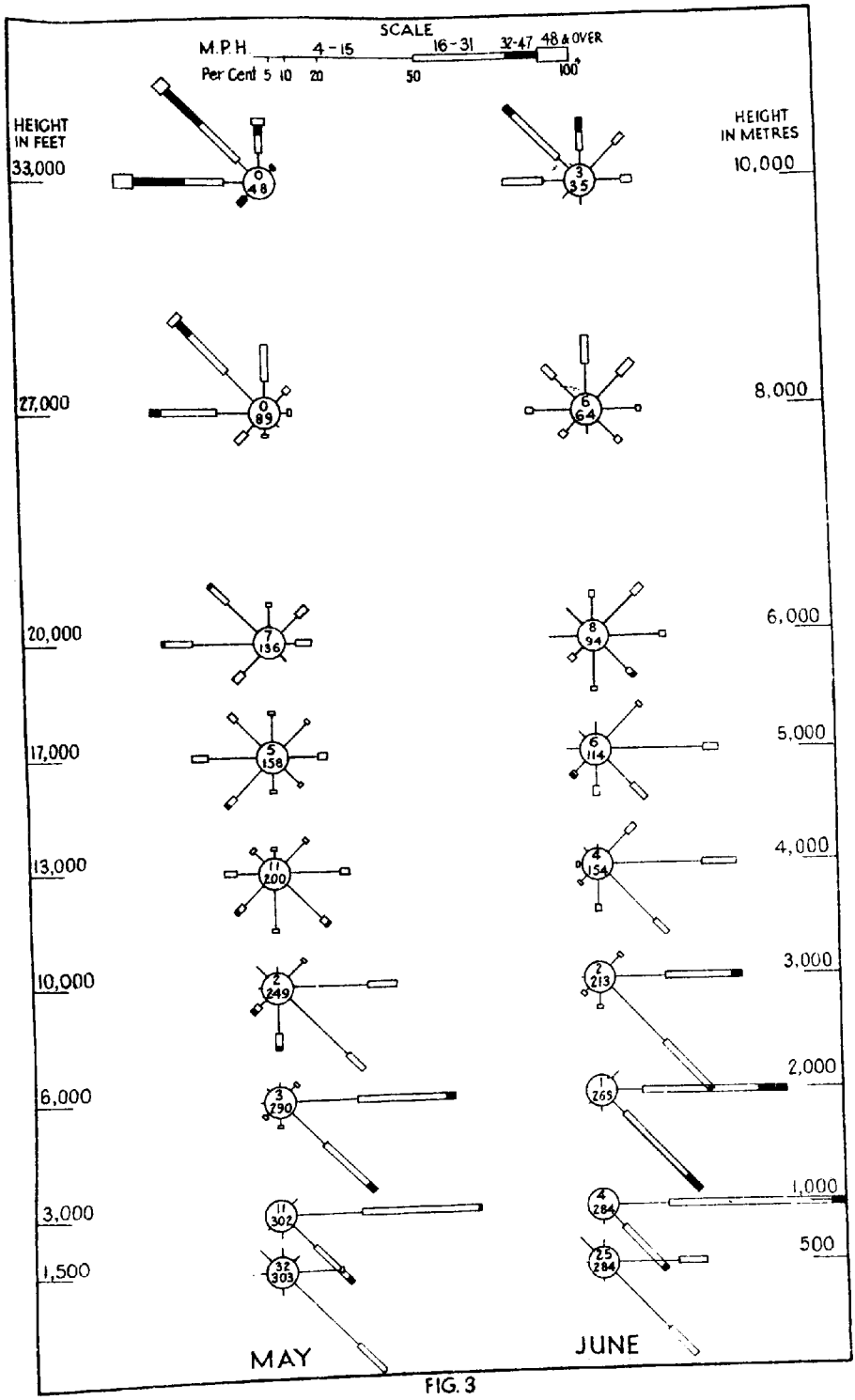
SCALE
M.P.H. 4-15 16-31 32-47 48 & OVER
Per Cent 5 10 20 50 100
HEIGHT IN FEET
33,000
27,000
20,000
17,000
13,000
10,000
6,000
3,000
1,500
HEIGHT IN METRES
10,000
8,000
6,000
5,000
4,000
3,000
2,000
1,000
500
0 48
3 35
0 89
6 64
7 136
8 94
5 158
6 114
11 200
4 154
2 249
2 213
3 290
1 265
11 302
4 284
32 303
25 284
MAY
JUNE

FIG. 3

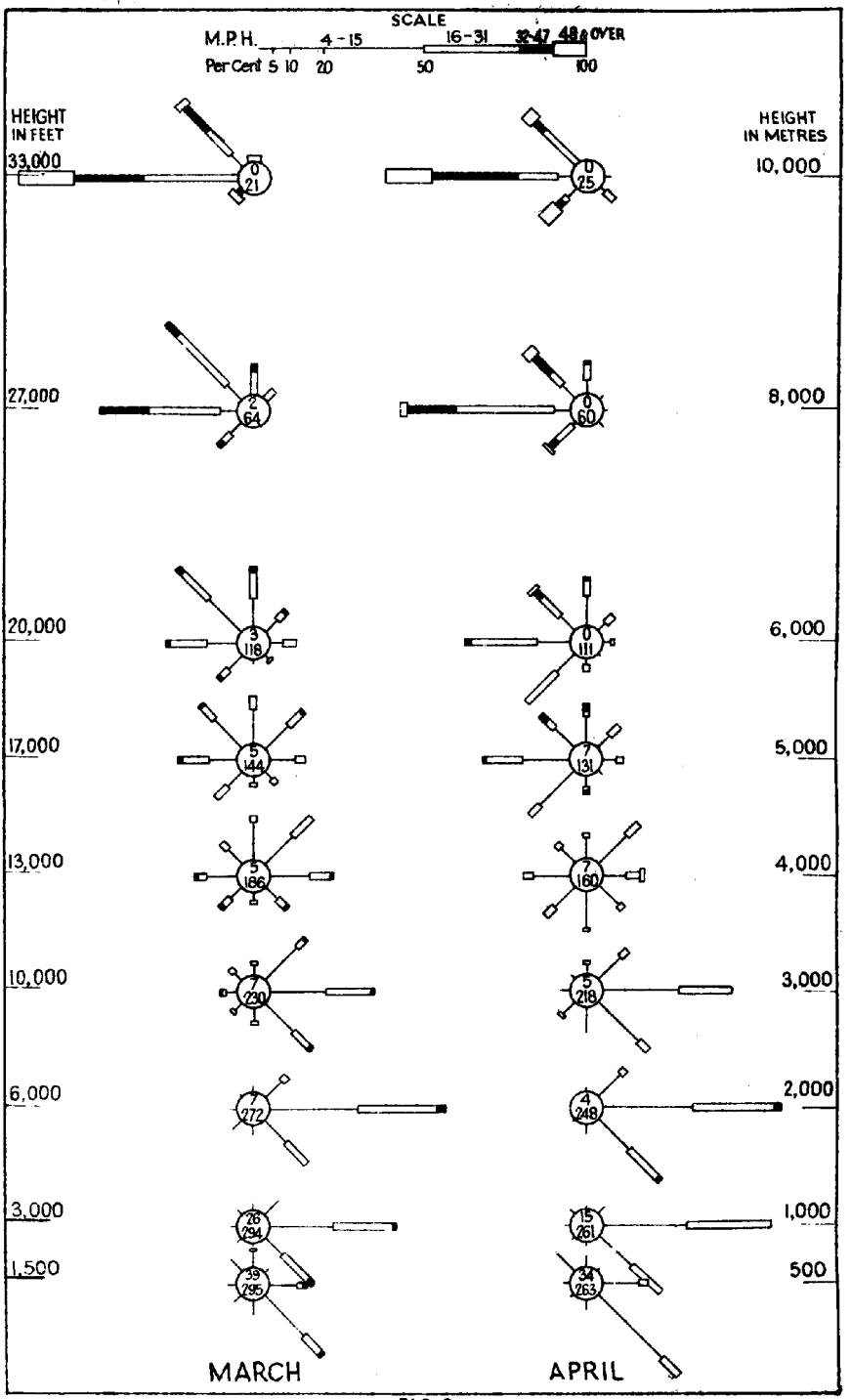
SCALE
M.P.H. 4-15 16-31 32-47 48 & OVER
Per Cent 5 10 20 50 100
HEIGHT IN FEET
HEIGHT IN METRES
33,000
10,000
27,000
8,000
20,000
6,000
17,000
5,000
13,000
4,000
10,000
3,000
6,000
2,000
3,000
1,000
1,500
500
0 21
0 25
2 64
0 60
3 118
0 111
5 144
7 131
5 186
7 160
7 230
5 218
7 272
4 248
26 294
15 261
39 295
34 263
MARCH
APRIL

FIG. 2

Plate IV

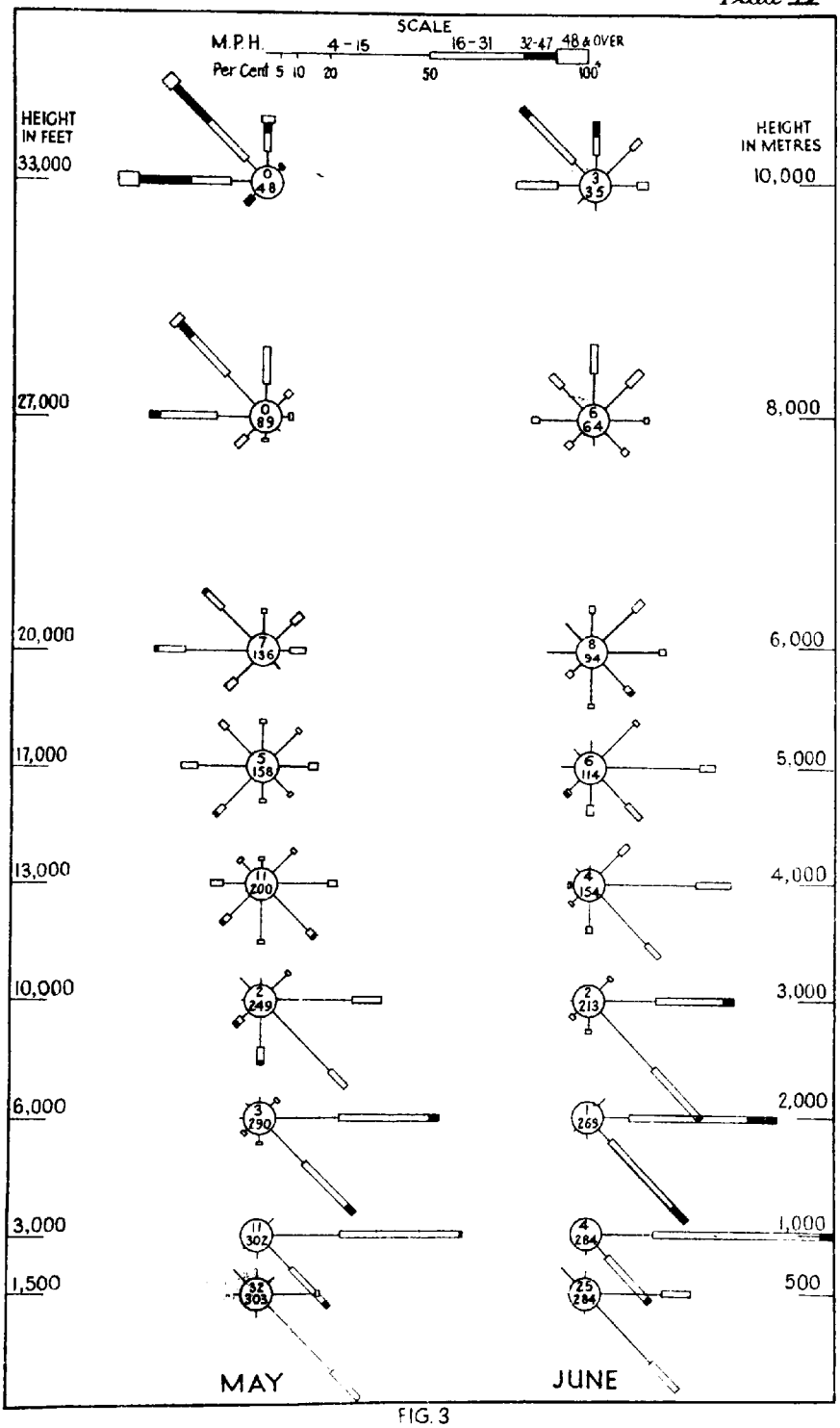

FIG. 3

Plate V

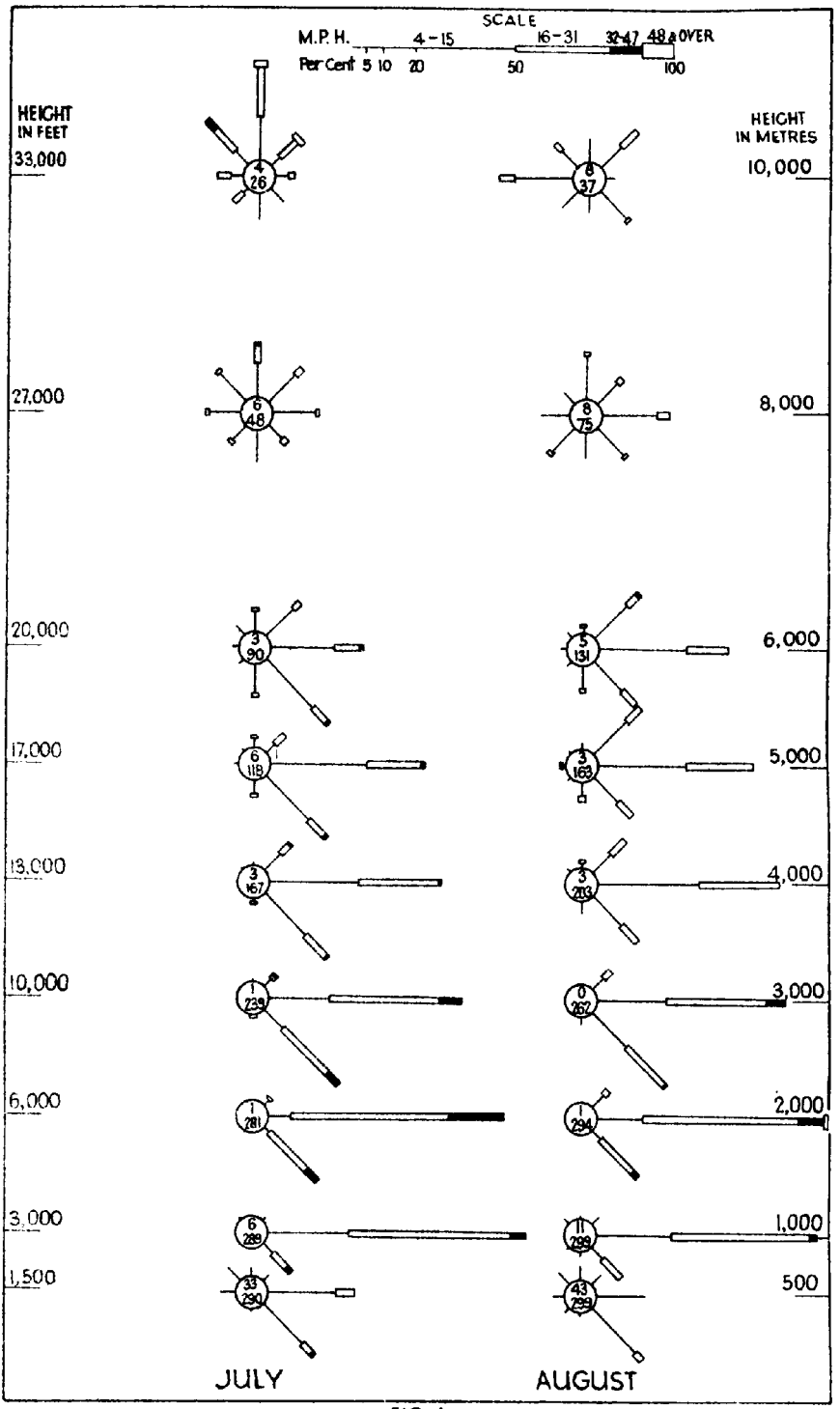
SCALE
M.P.H. 4-15 16-31 32-47 48 & OVER
Per Cent 5 10 20 50 100
HEIGHT IN FEET
33,000
27,000
20,000
17,000
13,000
10,000
6,000
3,000
1,500
HEIGHT IN METRES
10,000
8,000
6,000
5,000
4,000
3,000
2,000
1,000
500
4 26
8 37
6 48
8 75
3 90
5 131
6 118
3 163
3 167
3 203
1 239
0 267
1 281
1 294
6 286
11 299
33 290
43 299
JULY
AUGUST

FIG. 4

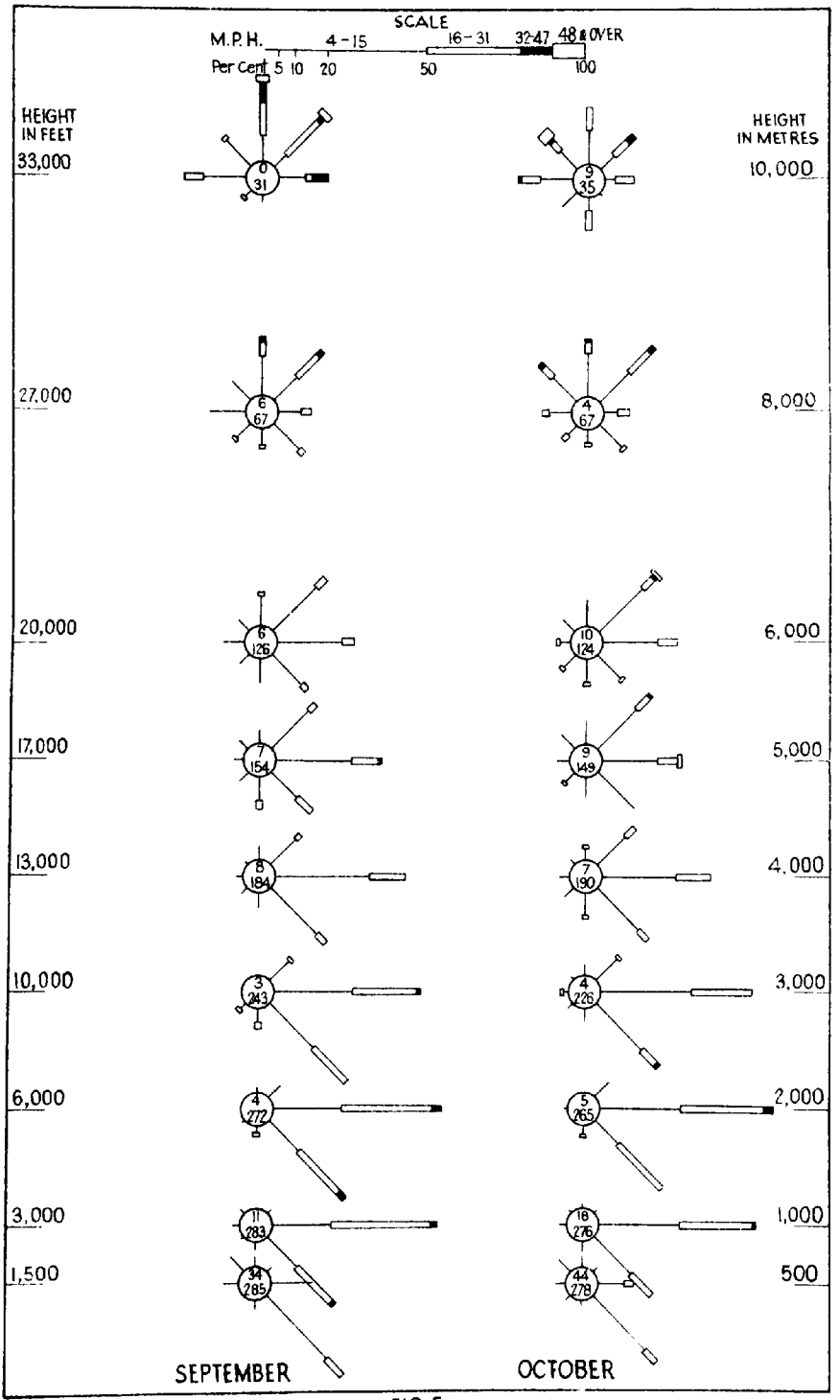
SCALE
M.P.H. 4-15 16-31 32-47 48 & OVER
Per Cent 5 10 20 50 100
HEIGHT IN FEET
HEIGHT IN METRES
33,000
10,000
27,000
8,000
20,000
6,000
17,000
5,000
13,000
4,000
10,000
3,000
6,000
2,000
3,000
1,000
1,500
500
0 31
9 35
6 67
4 67
6 126
10 124
7 154
9 149
8 184
7 190
3 243
4 226
4 272
5 265
11 283
18 276
34 285
44 278
SEPTEMBER
OCTOBER

FIG. 5

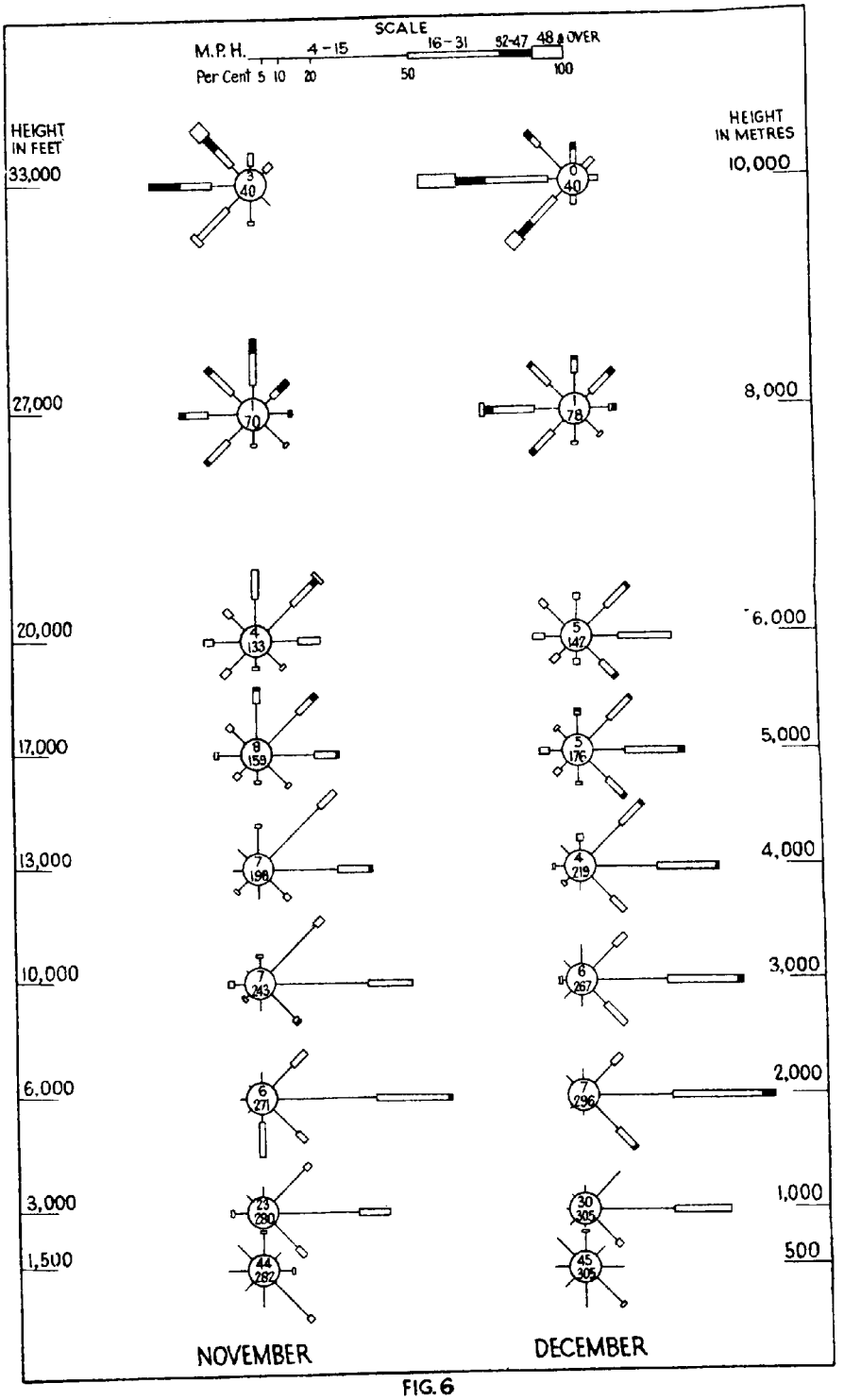
SCALE
M.P.H. 4-15 16-31 32-47 48 & OVER
Per Cent 5 10 20 50 100
HEIGHT IN FEET
33,000
27,000
20,000
17,000
13,000
10,000
6,000
3,000
1,500
HEIGHT IN METRES
10,000
8,000
6,000
5,000
4,000
3,000
2,000
1,000
500
3 40
0 40
70
1 78
4 133
5 147
8 159
5 176
7 196
4 219
7 243
6 267
6 271
7 296
23 280
30 305
44 282
45 305
NOVEMBER
DECEMBER

FIG. 6